

LA-UR--84-3578 DE85 003755

TITLE A PROPOSED METHOD FOR REMOTE THERMOMETRY IN TURBINE ENGINES

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SUBMITTED TO: AIAA/ASME/SAE 21st Joint Propulsion Conference July 8-10, 1985 Monterey, CA

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ABSTRACT

A Proposed Method for Remote Thermometry in Turbine Engines

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Introduction

A method developed recently for measuring temperatures remotely in operating gas centrifuges 1,2 may be adaptable to similar measurements in operating turbine engines. The method uses laser-induced fluorescence (LIF) from a pulsed uv laser to excite a rare-earth-oxide phosphor that is bonded in a thin layer to the surface to be measured. The luminescent decay times of certain spectral lines are well-behaved functions of temperature. These lines can therefore be used to measure the temperature with considerable accuracy (within 0.3°C in the centrifuge, near room temperature).

The first questions to be answered in a study are the following.

- 1. Is there a phosphor whose LIF is usable at the desired temperature?
- 2. If so, is it chemically nonreactive at that temperature and stable over multiple temperature cycles?
- 3. If there a suitable way to bond the phosphor to the alloys used in turbine engines such that it will adhere through temperature cycling and at speed?

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Given positive answers to these questions, there remain many engineering questions to be considered later.

In this paper we discuss initial experimental results on the first question and speculate about answers to the other two questions.

Experimental Technique and Results

An experiment was set up, as shown in Fig. 1, to measure the decay lifetime of the 612-nm line emitted from LIF of europium-doped yttrium oxide over the range from 300°C to the maximum obtainable from the oven, 930°C. A small hole was drilled in the stainless-steel case of the ceramic heater cartridge. A chromel-alumel thermocouple was mounted in the hole, flush with the surface. The phosphor was applied to the area around the hole. The oven chamber containing the cartridge was flushed with dry nitrogen during operation to minimize corrosion of the stainless steel. The LIF from the phosphor is excited by 337.1-nm radiation from the N₂ laser that was brought into the oven via an optical fiber. The LIF was focused on the entrance slit of the monochromator, which was used to select the 612-nm line. The same setup was used with the monochromator in its scanning mode to locate candidate spectral lines. The data from many laser pulses at a given temperature were gathered and analyzed by the Biomation transient recorder and the Tektronix waveform-processing oscilloscope.

The results are shown in Fig. 2. Above 700°C, the data are linear on a semilog plot, showing the desired well-behaved characteristic. The 612-nm line from this phosphor is not usable below 700°C, but there are other lines that are useful in this range.

The experimental setup is presently being modified to expand the temperature range to our goal of 1150°C.

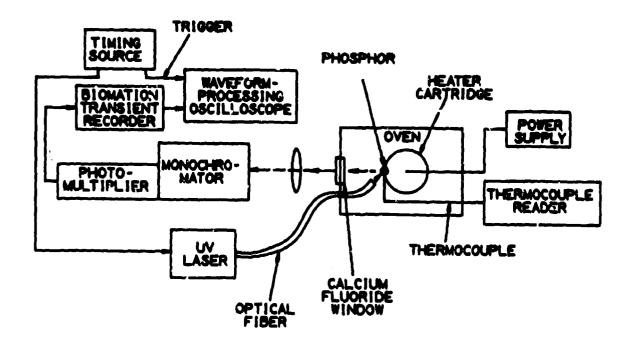


Fig. 1. Experimental setup for measuring pulsed laser-inducedfluorescence decay lifetime as a function of temperature for europium-doped yttrium oxide.

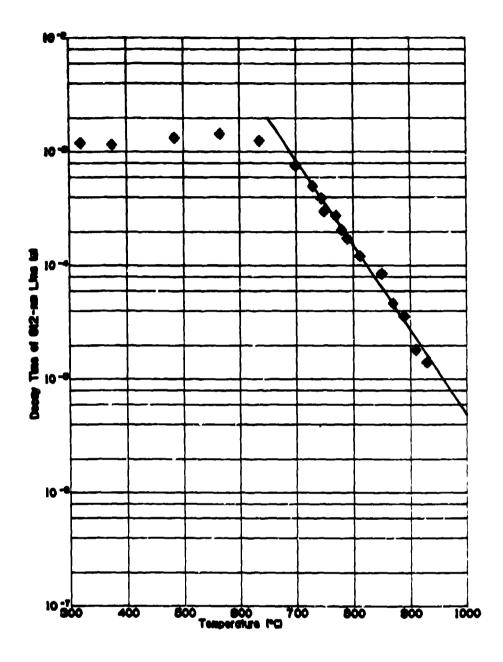


Fig. 2. Experimental results from setup in Fig. 1.

Speculations

The yttrium oxide, a ceramic, appears to be chemically inert to above 925°C. Whether it will be stable over several temperature cycles, or whether the europium dopant atoms will diffuse out, has not yet been determined.

Several bonding methods for high temperatures have been considered. These include sodium and potassium silicates, glass frits, sputtering, flame spray, and a new photoresist technique. Preliminary results show that the silicates are transparent to uv and can easily be sprayed. However, they are difficult to outgas completely of their trapped water vapor. It may be possible to improve this with a vacuum oven.

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